Exploration of Electronic Properties in "Materials Beyond Graphene": Transition Metal Dichalcogenides

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Keywords: transition metal dichalcogenide, MoS_2, WSe_2, $PdTe_2$, angle-resolved photoemission spectroscopy, electronic structure

Transition-metal dichalcogenides (TMD), or so called "materials beyond graphene", have gained much attention due to their properties which have higher potential for certain usages in optoelectronics, valleytronics, and spintronics. Among them, monolayer MoS_2 is one of the most-studied dichalcogenides. The transition from indirect (bulk) to direct band gap (monolayer) and controllable valley polarization are reported in atomically thin MoS_2. From our recent study, by using angle-resolved photoemission spectroscopy, we find that a quasi-freestanding MoS2 monolayer can be created on the surface of bulk MoS_2 by evaporating and subsequently intercalating potassium in the interlayer gap. This surface also exhibits strong spin-orbit coupling as expected in monolayer. And, more recently, we have experimentally observed a new type of spin character in bulk WSe_2. Furthermore, we also observed a pronounced effect of the so called "negative electronic compressibility" in WSe_2 where the chemical potential counterintuitively becomes lower upon increasing electron density; this allows more charge to be stored in this atomically-thin material, prompting application of high-density energy storage. If time allows, I will briefly discuss about our study of the topological quantum states in TMD and some basic concept in topological quantum computing.